Report for 2001TN4101B: Constructed Wetland Cleanup of Pirtle's Container Nursery Runoff

- Conference Proceedings:
    - Lansford, S.N., G.K. Stearman, D.B. George, K.L. Carlson, and C.D. Belew. 1998. Bulrush Response to Simazine and Metolachlor in Constructed Wetlands from a Container Nursery. In Agronomy Abstracts of the 1998 Annual Agronomy Meetings, October 18-22, Baltimore, MD, p.36
    - Stearman, G.K., D.B. George, E.W. Davis, and S.N.Lansford. 2000. Constructed Wetlands Removal of Herbicides and Nutrients from Container Nursery Runoff. SNA Research Conference Atlanta, GA, Vol 45:520-523.
    - Hutchings, L D.., G.K. Stearman, D.B. George, and C.W. Robinson. 2002. Nitrogen and Phosphorus Removal from Runoff in a Subsurface Flow Constructed Wetland. In Agronomy Abstracts of the 2002 Annual American Society of Agronomy Meetings, and presented Nov. 10, Indianapolis, IN.
- Other Publications:
    - Stearman, K.G., G. B. George, Constructed Wetlands at Pirtle?s Container Nursery, USA., 11th Tennessee Water Resources Symposium, Nashville, April4-6, 2001.
    - Stearman, K.G., G. G. George, Clean Water Using Constructed Wetlands in Container Nurseries: Guidelines for Construction, Maintenance and Costs, USA., Tennessee Department of Agriculture, Nonpoint Sources Program, #904-B-00-900, 11p.
    - Lansford, S.N., G.K. Stearman, D.B. George, and K.L. Carlson. 1998. Soft stem Bulrush Response to Simazine and Metolachlor in Constructed Wetlands from a Container Nursery. Tennessee Academy of Science, Cookeville, TN, November 20. Poster.
    - Stearman, G.K., S.N. Lansford, K.L. Carlson, and D.B. George. 1999. Pesticide and Nutrient Removal in Constructed Wetlands. Presented to the Ninth Tennessee Water Resources Symposium, American Water Resources Association, Nashville, TN, April 14
    - Stearman, G.K., D.B. George, E.W. Davis, and S.N. Lansford. 2000. Constructed Wetlands Removal of Herbicides and Nutrients from Container Nursery Runoff. Southern Nurserymen?s Association Annual Conference, Atlanta, GA, August 3-5.
    - Stearman, G.K., D.B. George, E.W. Davis, and S.N. Lansford. 2000. Constructed Wetlands Removal of Herbicides and Nutrients from Container Nursery Runoff. Tennessee Green Industry Field Day, Presentation, August 15, McMinnville, TN.
    - Stearman, G.K., D.B. George, and L. B. Hutchings. 2003. Constructed Wetland Cleanup of Pirle?s Container Nursery Runoff: Removal of Nitrogen, Phosphorus and Prodiamine from a Subsurface Flow Constructed Wetland at 1,2, and 3 day Hydraulic Retention Times. To be presented as a poster to the Thirteenth Tennessee Water Resources Symposium, American Water Resources Association April 9 Montgomery Bell State Park, Burns, TN.
- Articles in Refereed Scientific Journals:
    - Stearman, G.K., Dennis B. George, Kris Carlson, and Stacey Lansford. 2003. Pesticide Removal from Container Nursery Runoff in Constructed Wetalnd Cells. Journal of Environmental Quality. (accepted for publication).
    - George, D.B., G.Kim Stearman, Kristofer Carlson, and Stacey Lansford. 2003. Simazine and Metolachlor Removal by Subsurface Flow Constructed Wetlands. Water Environmental Foundation (in press)

- Dissertations:
    - Robinson, Charles Westley, 2002, Mathematical Description of Subsurface Flow (SF) Constructed Wetlands Using the Advection-Dispersion Mass Balance Equation. MS Dissertation, Civil and Environmental Engineering, Tennessee Technological University, Cookeville, Tennessee, 81 pps.
    - Lansford, S.N. 2000. Pesticide and Nutrient Removal from Container Nursery Runoff by Constructed Wetlands. MS Dissertation Biology, Tennessee Technological University, Cookeville, Tennessee, 128 pps.
    - Carlson, Kristofer, 1999, Subsurface Flow Constructed Wetlands as an Effective Practice for the Remediation of Potential Herbicide and Nutrient Contamination in Container Nursery Runoff, MS Dissertation, Civil and Environmental Engineering, Tennessee Technological University, Cookeville, Tennessee, 164 pps.

Report Follows:

6. Problem and Research Objectives:

Nurseries apply large amounts of agricultural chemicals to sloping terrains that are highly susceptible to soil erosion. Pesticides and fertilizers may run off into surface water causing detrimental effects to nontarget organisms. Identification and implementation of best management practices, including constructed wetlands, that reduce agricultural chemicals in waterways are essential to reduce agricultural chemical pollution of water resources. N and P removal in constructed wetlands have been reported in a few studies, while pesticide removal has seldom been studied in constructed wetlands.

A 192 m^2 gravel subsurface flow constructed wetland was designed and installed at Pirtle's Nursery in Smithville, TN February, 2000. The wetland was 45 cm deep and contained approximately $20 m^3$ of water. Softstem bulrush (*Scirpus validus*), cattails (*Typha latifolia* L.), and juncus (*Juncus* spp.) were planted in the wetland. A standpipe controlled water level in the wetland and a bypass pipe averted heavy flow. Total nitrogen (N), phosphorus (P), and the pesticde prodiamine were measured from the influent and effluent water during daily irrigation events.

The objective of this study was to determine the removal of nitrogen (N), phosphorus (P), and the herbicide prodiamine from irrigation runoff water at Pirtle's Nursery into a vegetated subsurface flow gravel constructed wetland at 1,2, and 3 d hydraulic retention times (HRTs).

7. Methodology:

Constructed Wetlands

The constructed wetlands are located at Pirtle's Nursery in Smithville, TN. Irrigation runoff water from a 1.0 ha container nursery pod flows into the wetland. The wetland is 45 cm deep and 25 x 7.68 m in surface area. The pore volume is estimated to be 20 m^3 based on 30% porosity. The media consisted of 22.5 cm depth of limestone gravel (diameter size 2.5-5.0 cm) overlain by finer gravel (diameter size 0.63-1.88 cm). The entrance to the wetlands held coarse gravel for the entire depth for a distance of 3 m so that flow into the wetlands was not restricted by the fine gravel. The wetland was planted primarily with soft stem bulrush, with cattails and juncus growing on the back edge of the wetland .

Sampling

Sampling dates were from May 16 until August 2, 2002. Effluent water samples were collected in a 1 L amber bottle each day prior to irrigation at 1230 h. Influent water samples were collected in a 1 L amber bottle each day at 1300 h, 30 min after irrigation began. Water samples were transported to the Water Center lab for analysis of N, P, and prodiamine.

Flow Determination

A water valve into the wetlands controlled hydraulic retention times (HRTs) of 1,2, and 3 d. The valve controlling water into the wetlands was set at 75, 60, or 50 % of full flow for 1, 2, and 3 d HRTs, respectively.The nursery runoff was channeled to a concrete box where it split. An overflow stand pipe transported the bulk of the flow beneath the wetland to the holding pond while a submerged orifice located approximately 2.5 cm (1in) from the bottom of the box discharged runoff to the wetland. The water depth or head in the flow splitter box was measured with a Stevens Recorder. Maximum head was 15.2 cm (6 in). Hydrographs obtained during runoff events were used to determine the head in the box as a function of time during the event. The submerged orifice equation was used to estimate the flow to the wetland

$Q = C_d A_o \sqrt{2g(h_i-h_o)}$

Where,

Q = the discharge flow through the orifice (cfs),
C_d = coefficient of discharge (dimensionalless),
A_o = Orifice cross-sectional area (ft^2),
G = acceleration of gravity (fps),
H_i = water head (ft) at any specific time, and
H_0 = water depth to lower invert of orifice (ft).

The coefficient of discharge, C_d, was computed by measuring the discharge flow at various control valve settings. The control valve limited the flow to the wetland.

Valve (%)	Flow (cfs)	Flow (gal/d)	Orfice Area (sqft)	h (ft)	Cd
100	0.0740	47824	0.04908739	0.375	0.306763
75	0.0444	28694	0.03681554	0.375	0.245411
60	0.0226	14606	0.02945243	0.375	0.156145
50	0.0191	12344	0.02454369	0.375	0.158356

Water inflow at these valve settings had been measured previously to determine appropriate settings. Irrigation began at 1230 h every day. A Stevens chart recorder recorded the water level in the flow distribution box during daily runoff of irrigation.. Water influent (L) was computed using the hydrograph from the Stevens chart recorder and the hydraulic head orifice equation.

N, P, and Prodiamine Analysis

Total N was conducted using the persulfate digestion method and analyzed on a TRAACS 800 Auto Analyzer using the cadmium reduction method. Total P was digested by a mild acid hydrolysis and analyzed using the ascorbic acid colorimetric method (Murphy-Riley technique). Prodiamine was extracted with isooctane and analyzed by gas chromatography with an electron capture detector.

8. <u>Principle Findings and Significance:</u>

N, P and Prodiamine Removal in the Constructed Wetland

Mean N removal was 70 to 72% of total influent N. with a standard deviation of 8%. There was no difference in N removal from 1 to 3 day HRTs. Mean P removal varied from -2 to 10% of total influent P with a standard deviation of almost 40%. The erratic nature of phosphorus adsorption was largely attributed to pH shifts in water especially rain water which was acid. The irrigation water runoff was above 7.5 and the outflow water was usually around pH 8. The acidification of water caused phosphorus to dissolve from the alkaline wetland. Also sorption sites become saturated and as pH shifts downward phosphate is released into solution Mean prodiamine removal ranged from 49-65% of total influent prodiamine. Prodiamine removal was consistent with previous studies at Baxter, TN using constructed wetland cells. Results from the Baxter study showed that pesticides simazine and metolachlor were removed at 60-65% at 2 and 3 day retention times.

Mass of N entering and mass of N removed from the wetland were positively correlated. Maximum N concentration entering the wetland were 30 mg/L.

Removal Processes

N was removed primarily by denitrification with some plant removal. Nitrification is the rate limiting step in the denitrification process. Three days apparently is not enough time for all N conversion into nitrate so that denitrification can proceed in the wetland system. P was removed primarily by adsorption/precipitation reactions. P effluent values varied widely due to pH shifts in the wetland, especially during and after rain events. Prodiamine was removed both by microbial degradation and sorption.

Significance

Subsurface flow constructed wetlands are a promising technology for removal of N and pesticides from container nursery runoff. P removal was more problematic due to finite wetland gravel sorption sites and variation in runoff pH water due to acid rain. More research is needed to examine and implement technologies efficient in removing P that could be utilized with constructed wetlands.

The wetland required little maintenance other than occasional sediment removal after heavy rain, occasional sediment flushing of the inflow pipe to maintain flow and weed removal.

A poster was presented at the Annual Agronomy Meetings in Indianapolis November 10, 2002 and published an abstract for the same conference. Hutchings, L.D., G.K. Stearman, D.B. George, C.W. Robinson. Nitrogen and Phosphorus Removal from Runoff in a Subsurface Flow Constructed Wetland. Annual American Society of Agronomy Meetings, Indianapolis, IN. November 10, 2002.

9. <u>Future Research and Funding :</u>

A contract from the Tennessee Department of Agriculture 319 Non-Point Source Pollution Program through EPA entitled "Peat Application to Constructed Wetlands for Pesticide Cleanup at a Nursery" was awarded and began July 1, 2002. On November 30, 2002 the contract from USDA on "Pesticide Fate and Removal in Constructed Wetlands" was completed..